

**The challenge for earthquake disaster  
mitigation**

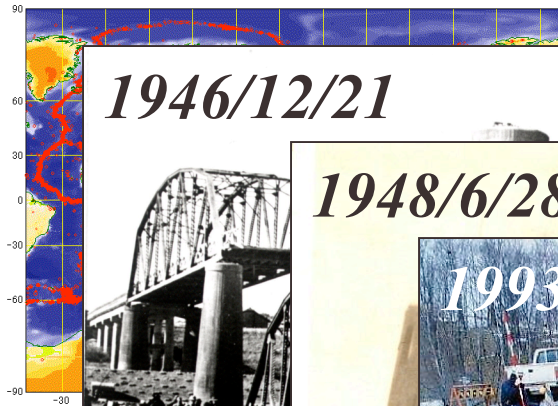
# **Estimated Seismic Intensity and Earthquake Early Warning**

**Shin'ya TSUKADA**

*Japan Meteorological Agency*



# Fated surroundings



1946/12/21



1948/6/28



1993/1/15



1993/7/12



1995/1/17



2000/3-





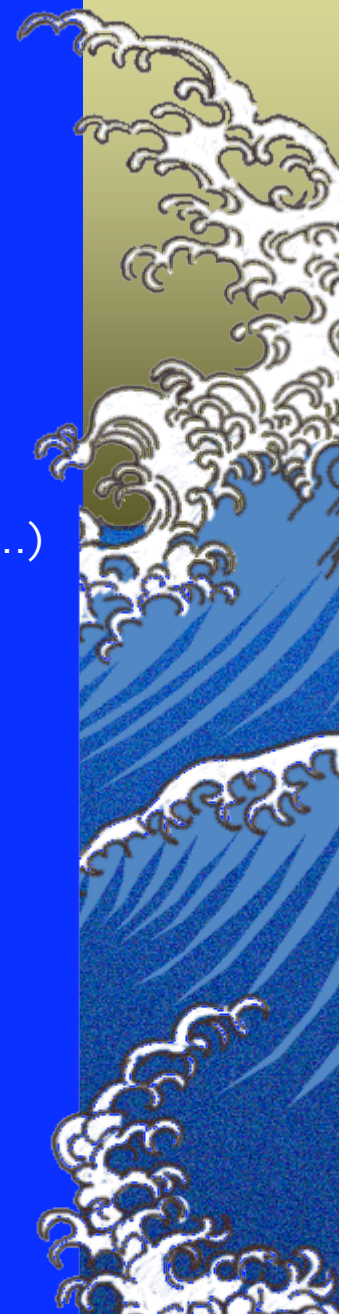
# What's the JMA's Mission?

**Japan Meteorological Agency (JMA)**



- \* **Tsunami Forecast**
- \* **Earthquake Information** (Hypocenter, Seismic intensity, .....)
- \* Earthquake Prediction (Tokai Earthquake)
- \* Volcano Information
- \* Comprehensive Bulletin on Earthquake and Volcano

**Earthquake and Volcano Information  
for Disaster Mitigation**



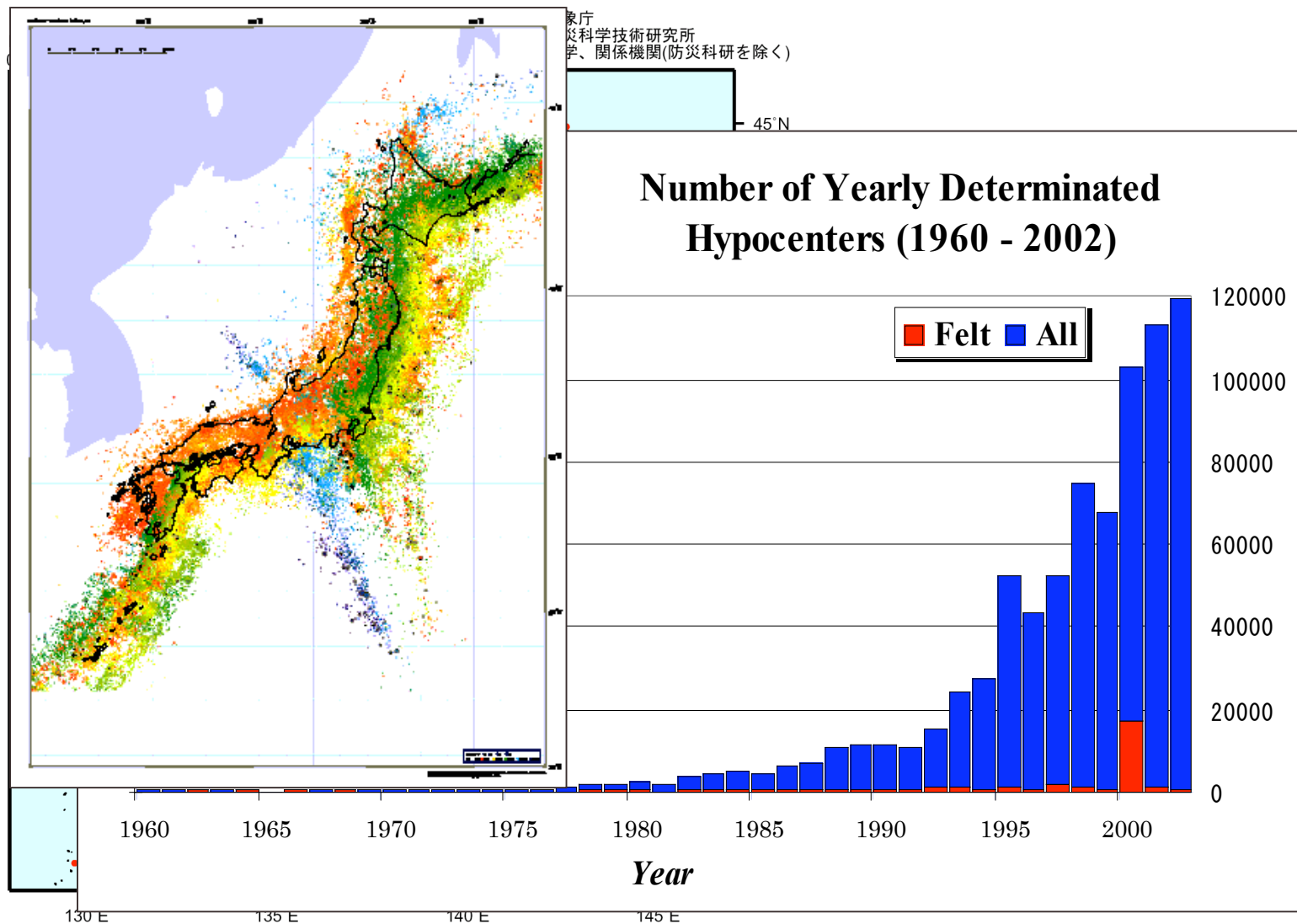
# Recent great progress of science and technology

- \* New knowledge of earth science
- \* Progress of computer technology
- \* Increase of seismic stations
  - > Increase of various seismic datum





# Revolution in seismic station network in Japan



# Our New Challenges

- \* Estimated Seismic Intensity Map
- \* Earthquake Early Warning
  - > ( = Real time Seismology)



# Seismic Intensity

1884 Initiation of Systematic Measurement of Seismic Intensity  
(human perception and the resultant damage)

1908 Rank 0 to 6

1949 Rank 7 is added after the Fukui Earthquake

1996 The Seismic Intensity 5 and 6 were subdivided  
respectively  
to 5-lower and 5-upper, and to 6-lower and 6-upper  
(automatic measurement by a seismic intensity meter)

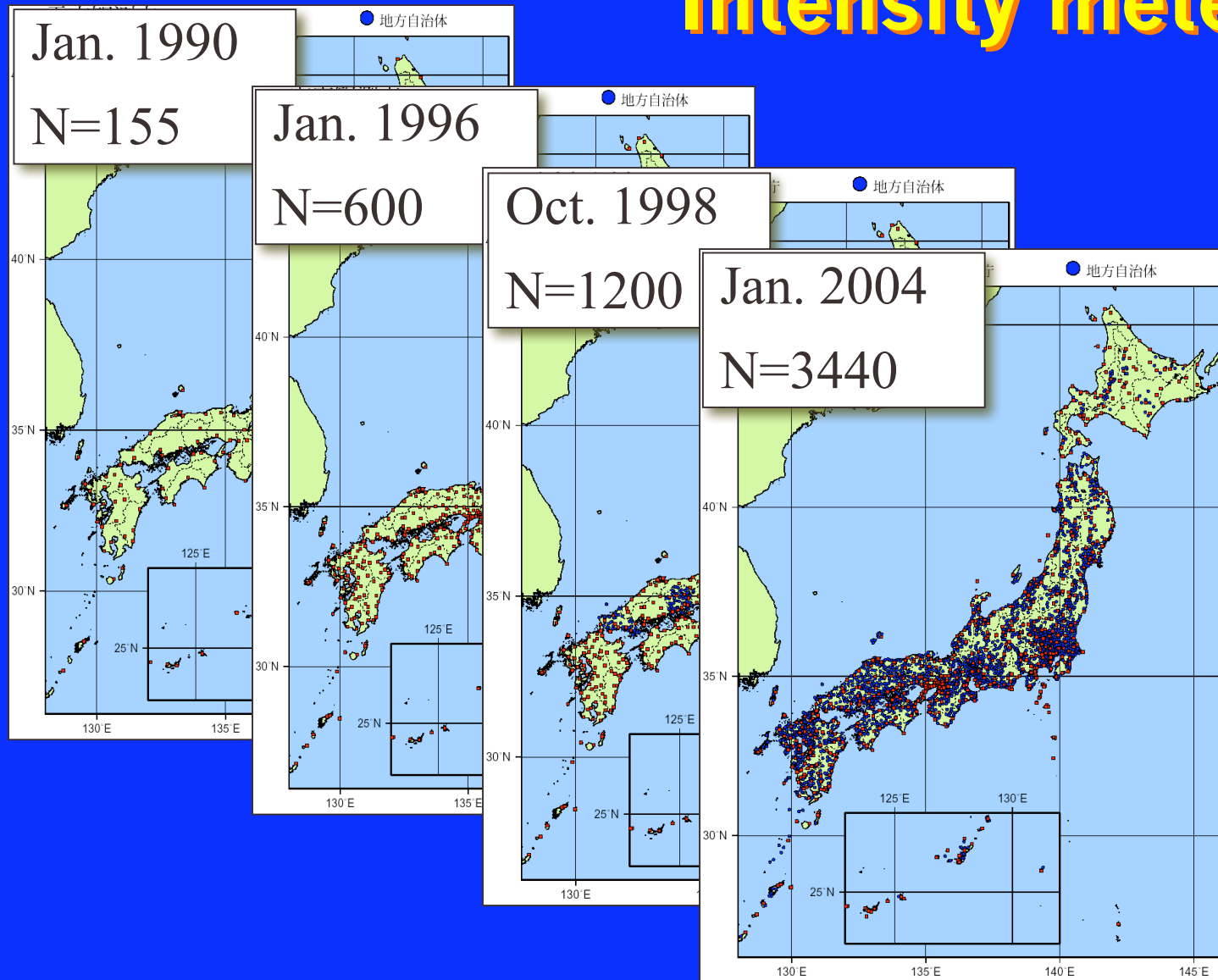
JMA SCALE	0	1	2	3	4	5L	5U	6L	6U	7		
MM SCALE	1	2	3	4	5	6	7	8	9	10	11	12

2004 Estimated Seismic Intensity Map





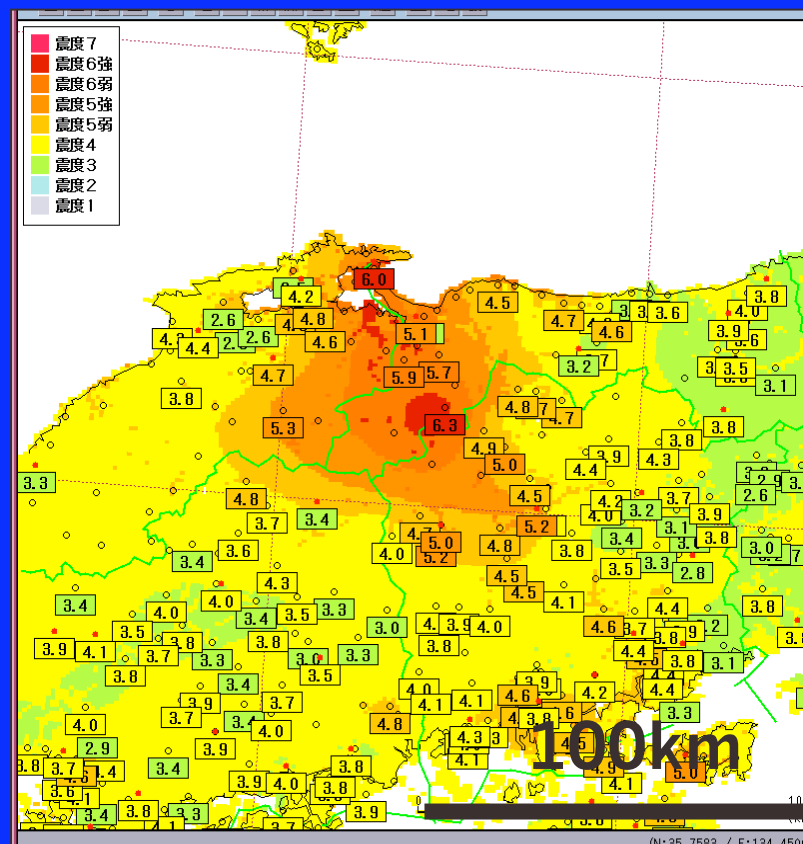
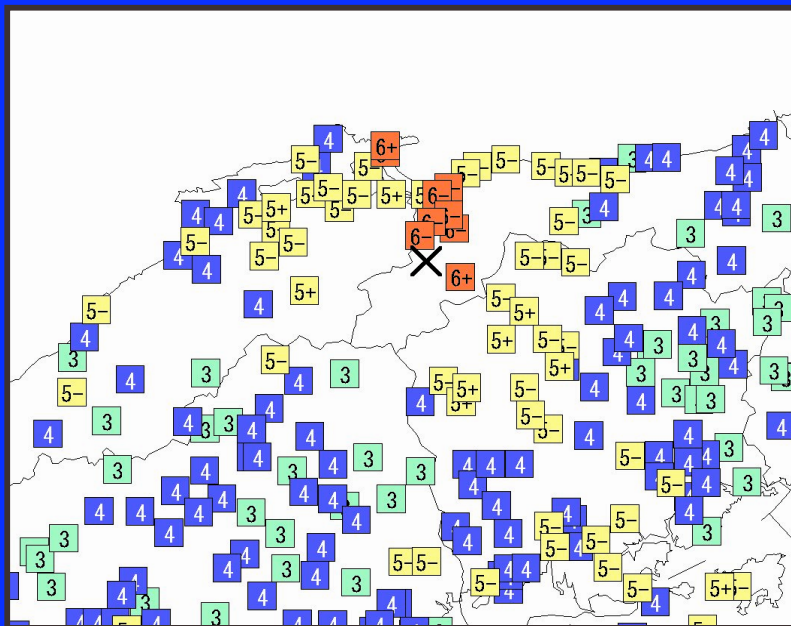
# Development of Seismic Intensity meters



# Estimated Seismic Intensity Map

Estimated

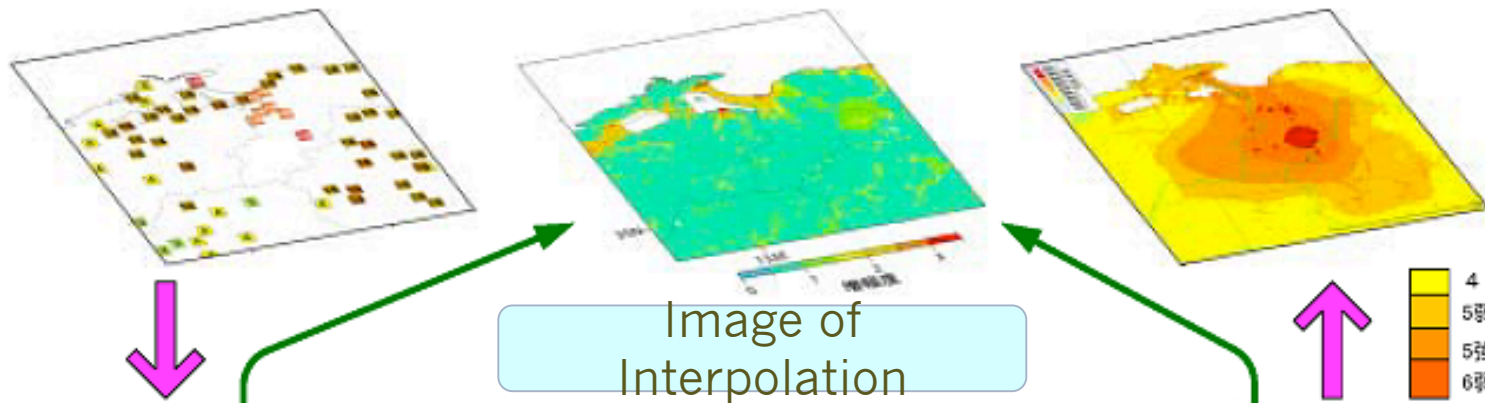
Observed



Observed  
Seismic  
Intensity

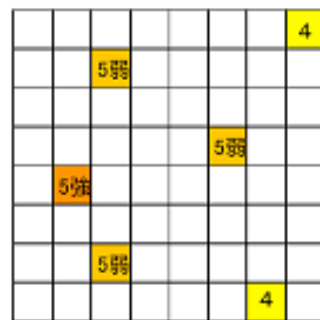
Site Amplification Factors  
given for every 1km mesh

Estimated  
Seismic  
Intensity



①

Estimate the  
Seismic Intensity  
at the Engineering  
Bed Rock level  
using the Seismic  
Intensity Observed  
at each Site on  
Surface and Site  
Amplification  
Factors



Estimate the Seismic Intensity at the  
Engineering Bed Rock level for  
every 1km Mesh by Interpolation



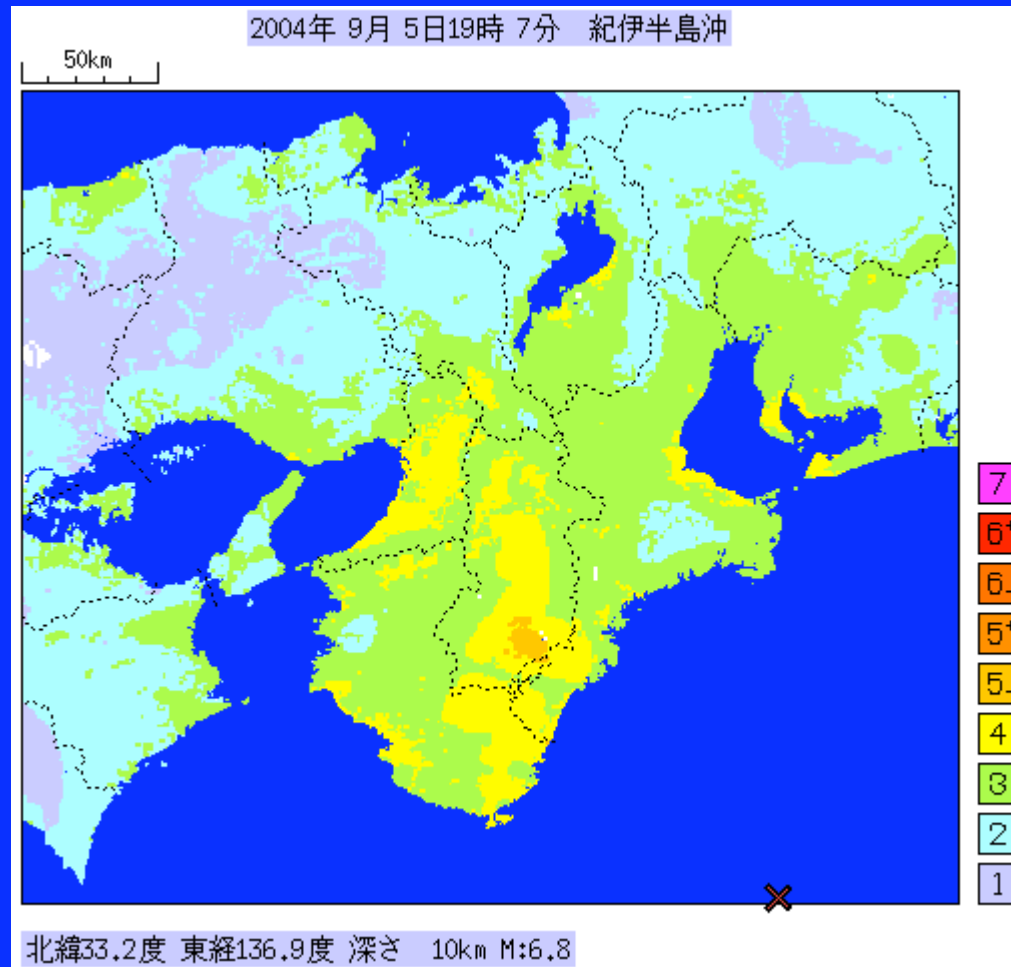
③

Estimate the  
Seismic Intensity  
on Surface for  
every 1km Mesh  
from Data and  
the Site  
Amplification  
Factor at each  
Mesh

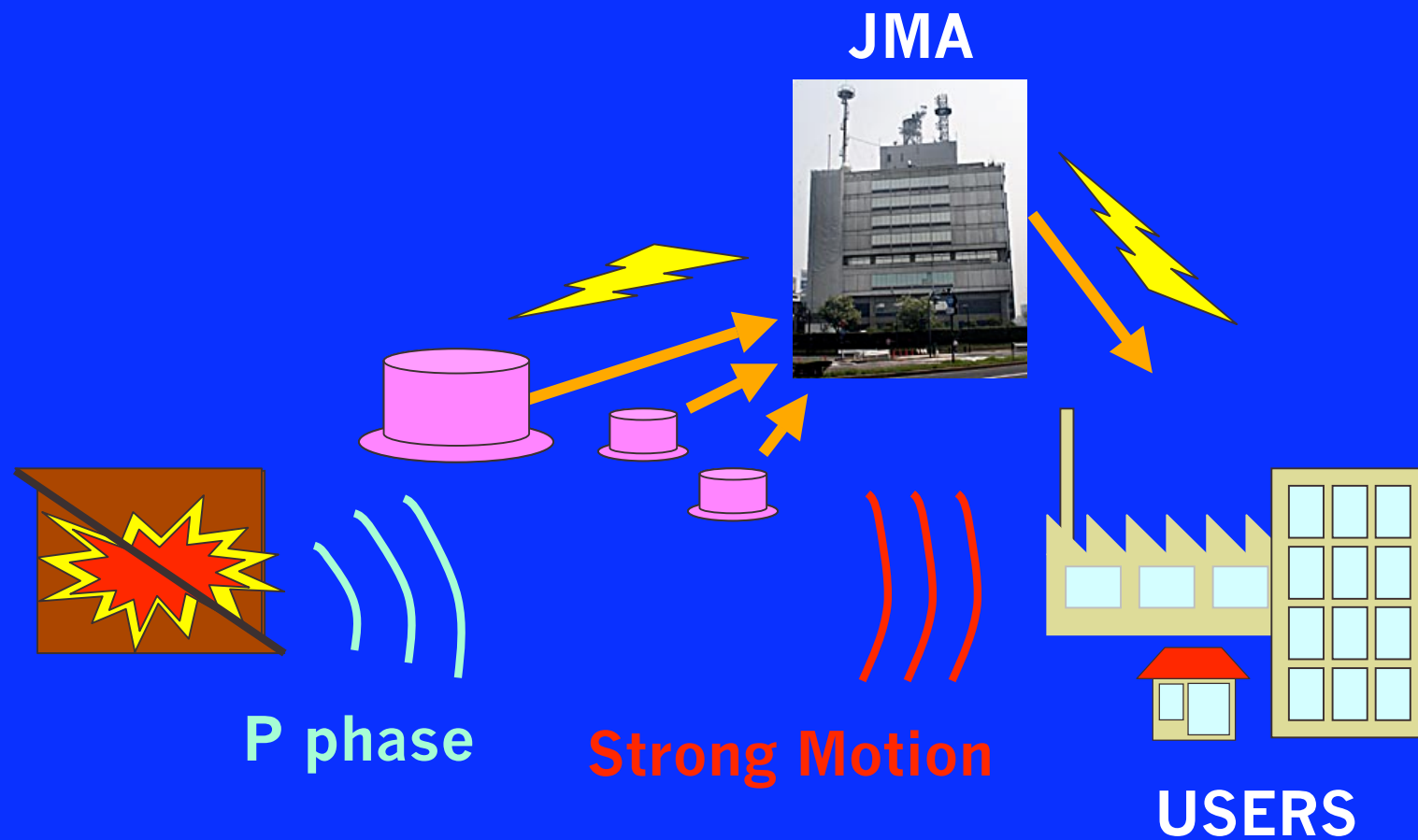


# Estimated Seismic Intensity Map

5th September 2004 Off Kii-Peninsula Earthquake (M6.9)



# Earthquake Early Warning



# San Francisco Daily Evening Bulletin

## by J.D. Cooper, M.D., November 3, 1868.

A very simple mechanical contrivance can be arranged at various points from 10 to 100 miles from San Francisco, by which a wave of the earth high enough to do damage will start an electric current over the wires now radiating from this city and almost instantaneously ring an alarm bell, which should be hung in a high tower near the center of the city



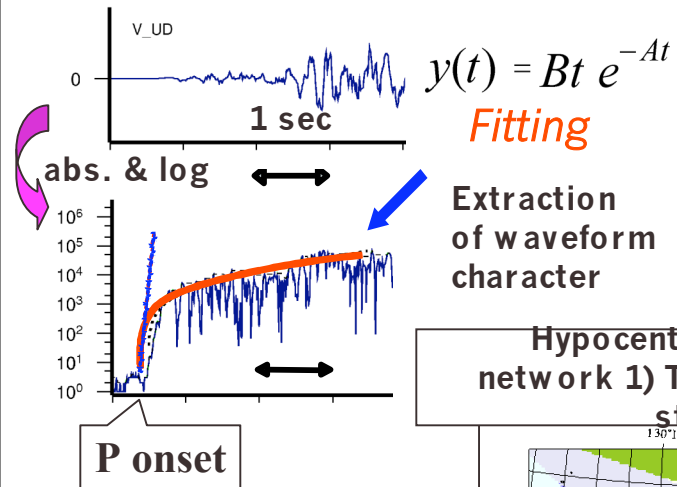
Continued in the spinning wheel.—At a distance of 100 miles from San Francisco, by which a wave of the earth high enough to do damage will start an electric current over the wires now radiating from this city and almost instantaneously ring an alarm bell, which should be hung in a high tower near the center of the city

**Earthquake Indicator.**  
**Editor Bulletin.**—Since the Japanese magnet indicator has proved a failure, we are now obliged to look for some other means of prognosticating these fearful convulsions, and I wish to suggest the following mode by which we may make electricity the means, perhaps, of saving thousands of lives in case of the occurrence of more severe shocks than we have yet experienced. It is well known that these shocks are produced by a wave-motion of the surface of the earth, the waves radiating from a centre just as they do in water when a stone is thrown in. If this centre happens to be far enough from this city, we may be easily notified of the coming wave in time for all to escape from dangerous buildings before it reaches us. The rate of velocity, as observed and recorded in Dr. J. B. Trask's work on earthquakes, published from 1800 to 1864, is about 100 feet per second, or a little less than half the rate of the tidal wave is reported to have travelled across the ocean to this port from Japan. In such a case, a contrivance can be arranged at various points from 10 to 100 miles from San Francisco, by which a wave of the earth high enough to do damage will start an electric current over the wires now radiating from this city, and almost instantaneously ring an alarm bell, which should be hung in a high tower near the center of the city. This bell should be hung in a high tower, and known to everybody as the earthquake bell. Of course nothing but the vibration of the surface of the earth should start the machinery would be self-acting, and not dependent on the telegraph operators, who might not always retain presence of mind enough to telegraph at the moment, or might sound the alarm too often. As some shocks appear to come from the west, a cable might be laid to the Farallone Islands, 25 miles distant, and warnings thus given of any danger from that direction. Of course there might be shocks the central force of which was too near this city to be thus predicted, but that is not likely to occur once in a hundred times.  
 J. D. Cooper, M.D.



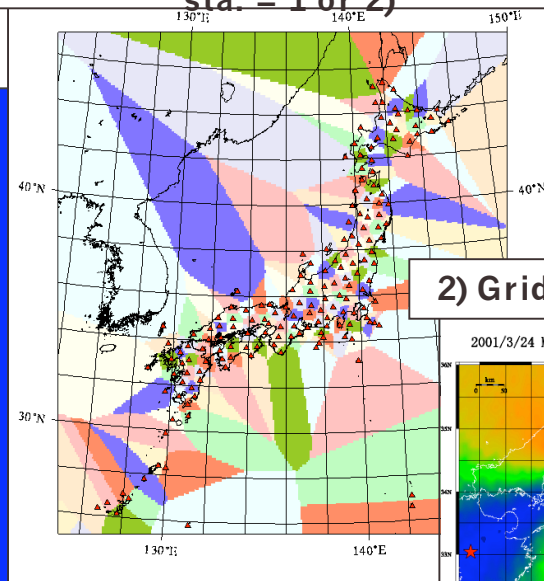
# Method of “Earthquake Early Warning”

Epicenter estimation from a single station

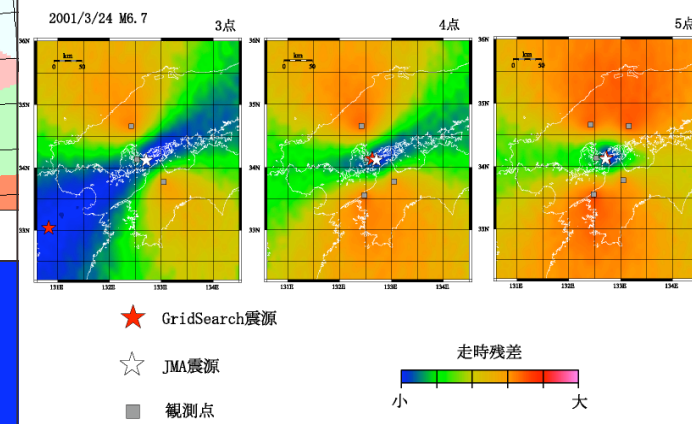


Extraction of waveform character

Hypocenter estimation from a network 1) Territory method ( # of sta. = 1 or 2)

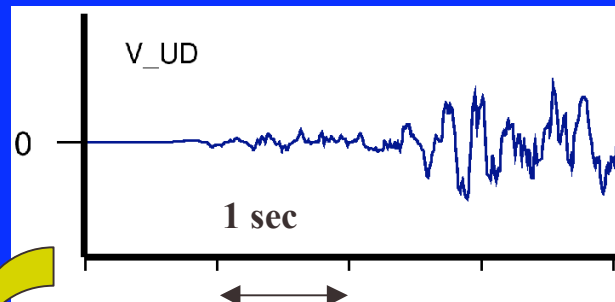


2) Grid search method ( # of sta. = 3 to 5)



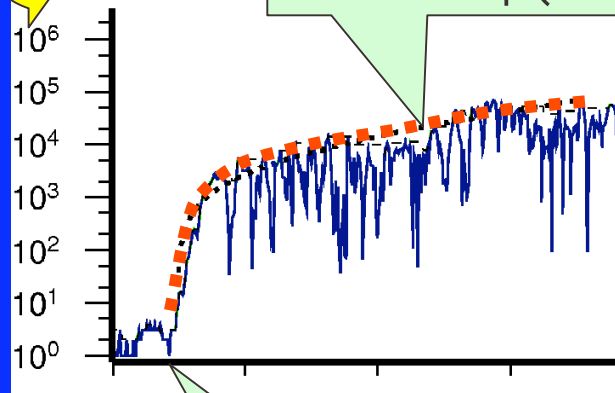
# Epicenter estimation from a single station

<< Extraction of waveform character → “A” & “B” >>

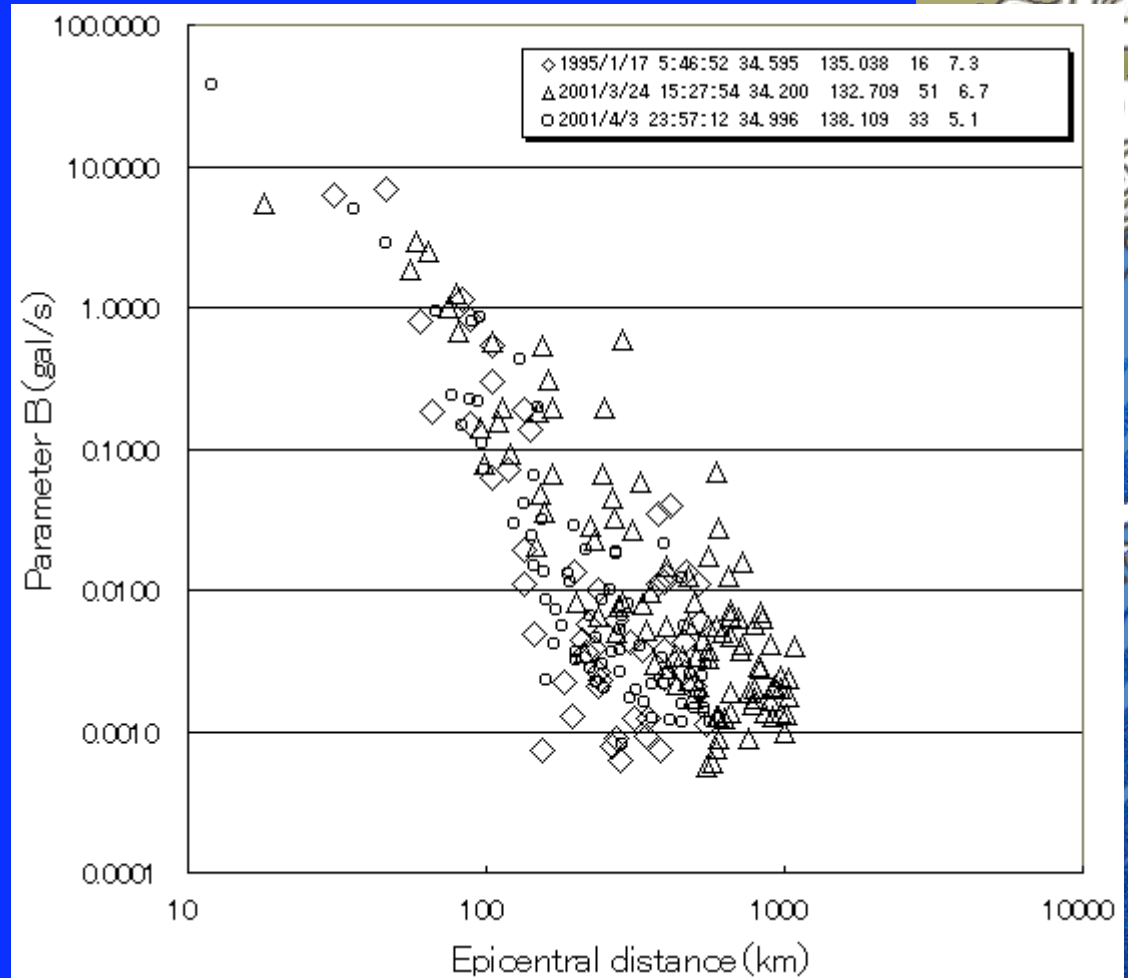


abs. & log

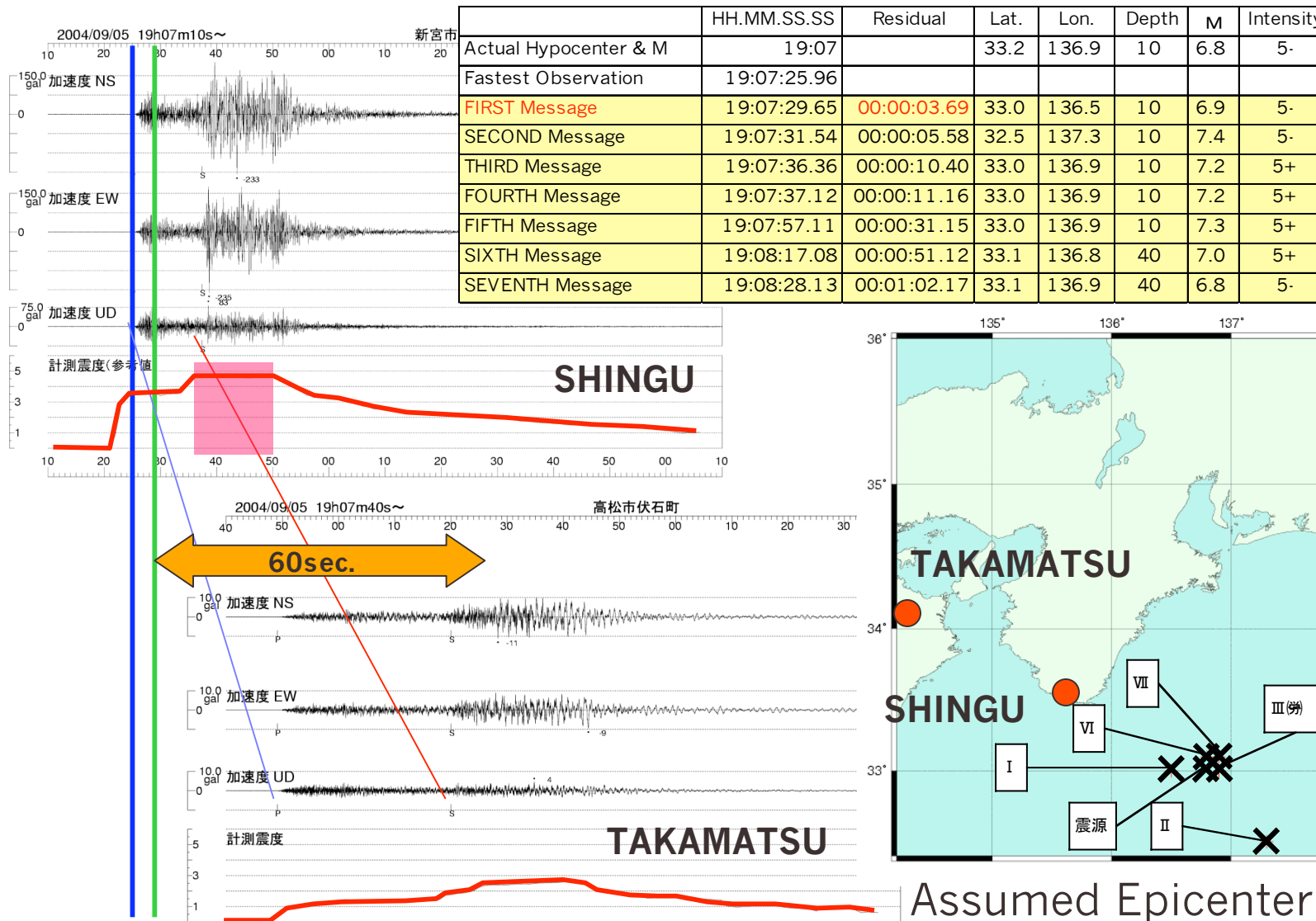
fit  $Bt \cdot \exp(-At)$



P onset

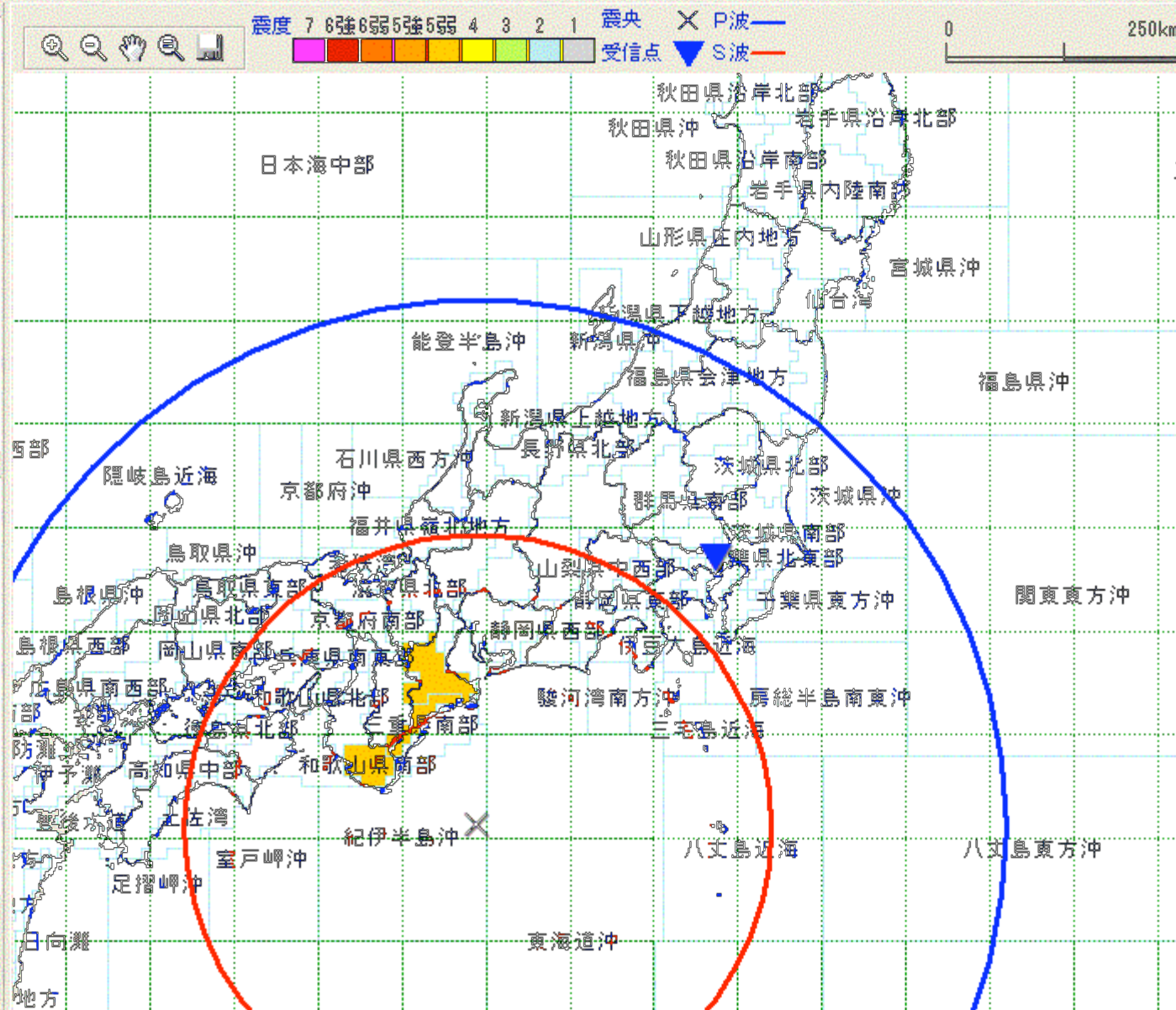


# Time Left at Each City before the Arrival of Strong jolt after the issuance of Earthquake Early Warning





Japan Meteorological Agency



# Challenge to earlier TSUNAMI Information

1941 Initiation of  
TSUNAMI Warning Service  
Manually ( 15 - 20 min )



1980's Interactive hypocenter determination  
by computer ( 12 - 13 min )

1990's Automatic processing ( 7- 8 min )

1999 Application of a Numerical Simulation (3 min )

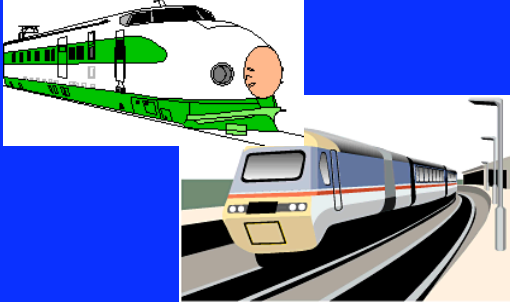
2005 ? Application of **an Earthquake Early Warning**  
(30sec - 1 min ? )





# Application of Earthquake Early Warning

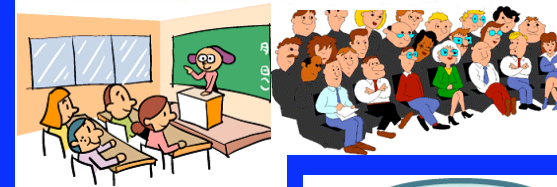
## Train Control System



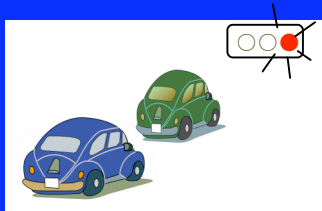
## Closing of the slide Against Tsunami



## Precaution measures for home / school / hall / shopping mall / etc



## Control Traffic Signals, Regulation of Traffic



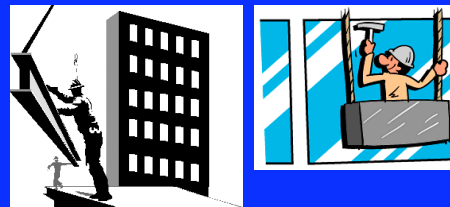
## Early Evacuation from Tsunami



## Hospital →Prevent Mistake in the Operation



## Lift Control System



## Person in Dangerous Place →Make Safe

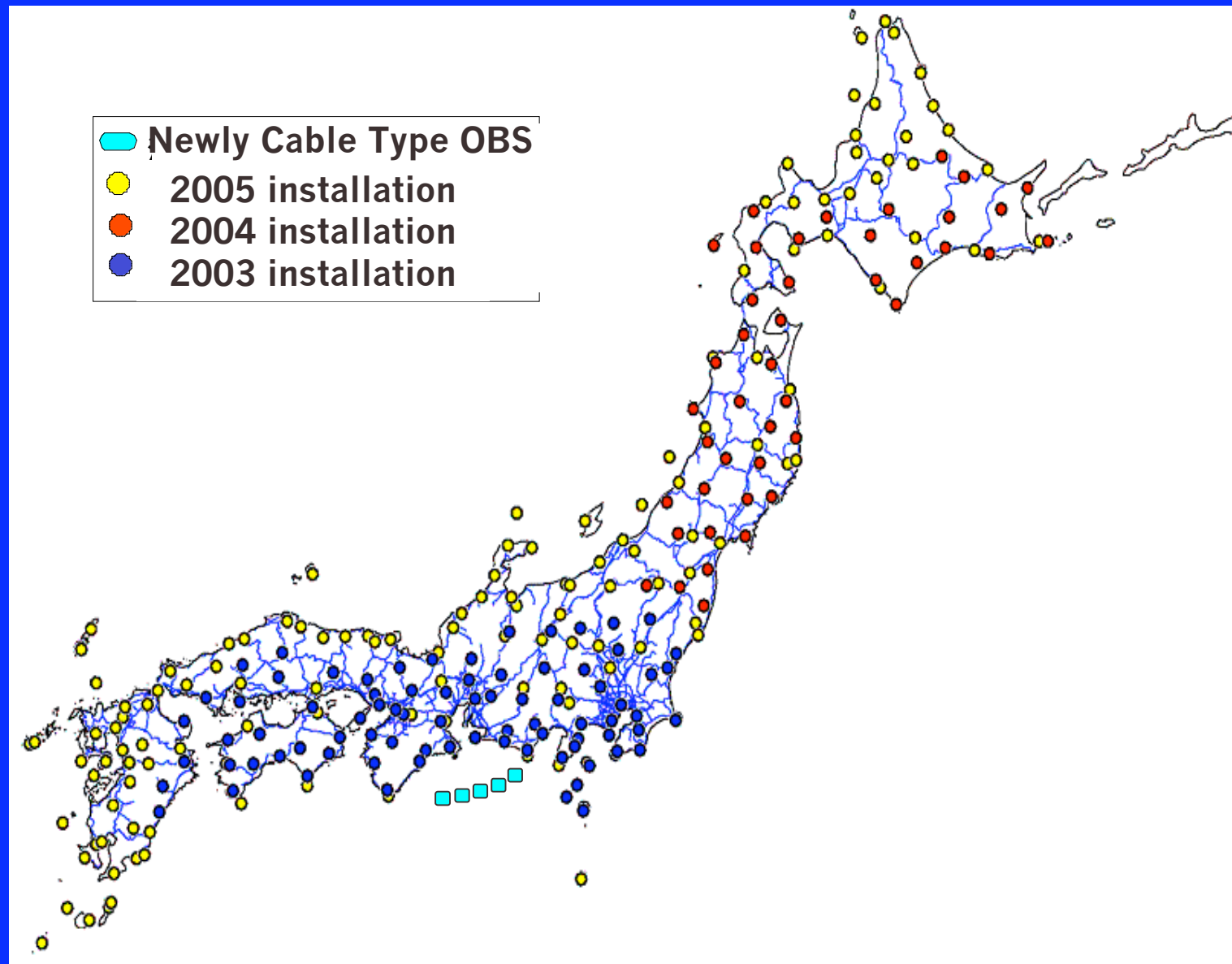


## Broadcast





# Schedule of New type Seismograph Placing



# Summary

JMA is issuing  
“Estimated Seismic Intensity Map”  
and  
“Earthquake Early Warning”  
experimentally since Feb. 2004.

*\* Optimum usage of the information  
corresponding to the timing & reliance*

*\* Understandings and Acceptance by public*

*\* Information Communicative technology*

